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A Systematic Review on 5G Massive MIMO Antennas

S. R. Mugunthan

Associate Professor, Department of Computer Science and Engineering, Sri Indu College of Engineering and Technology, Hyderabad, India

E-mail: srmugunth@gmail.com

Abstract

5G mobile network technology is commonly considered as the most established wireless communication paradigm. With the well-established growth of mobile technology, mobile networks were used to solve a wide range of challenges. 5G is considered as the first mobile network to provide high-speed internet access at any time and in any location. The distinct characteristics of 5G, such as enhanced user experience allows users to remotely connect and operate devices, objects, and equipment, differentiate them from conventional 4G technology. As a result, determining where the commercial may benefit from the adoption of the 5G network is crucial. The efficiency of 5G mobile communication technology assessments is evaluated in this research study by employing massive MIMO antennas.

Keywords: 5G antenna, MIMO, LTE, ultra-low-latency communications, antenna gain

1. Introduction

It's easier to transmit information if more antenna modules are deployed, which means that each antenna requires a smaller shaft. To achieve a substantial antenna gain, channel status information (CSI) is necessary on both the transmitter and the receiver. Industrial and research groups across a wide range of industries are growing interested in the future fifth wireless mobile generation, which is slated to be released in 2020. A paradigm change in wireless communications is envisaged as a result of this new standard's massive efforts on both the system and hardware levels. As a result of the intense rivalry among researchers, more attention has been paid to 5G.

5G mobile communications have emerged as a major issue in recent years as wireless technologies for communications have grown in popularity. Antennas, filters, amplifiers,

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mixers, and other Radio Frequency frontend components are essential for every wireless device or system. That's why antennas and circuits with cutting-edge technology are in such great demand.

Most traditional systems, on the other hand, struggle to meet the high bandwidth, radiation pattern, size, and cost requirements of 5G mobile communications. For this reason, researchers from both academia and industry are interested in developing the advanced 5G mobile antenna applications. Antenna and circuit design for future communication systems using microwave and millimeter-wave frequencies is the focus of this special issue, which welcomes high-quality submissions.

It has recently been suggested to use matching networks with lumped components [1, 2], reconfigurable frequency technology [3, 4], and multimode resonance approach [5, 6] to increase the bandwidth of mobile phone antennas. Also presented was an eight-band WWAN / LTE monopole antenna with a high-pass matching circuit that was lumped into a single device. However, the resistance of the matching circuit will create extra losses since the matching course is not optimum. Furthermore, it makes the working frequency range more sensitive to the value of lumped components.

1.1 Evaluation of Communication

A dramatic shift from 1G to 4G in wireless communication occurred in the last three decades. The need for large bandwidth and minimal latency was the driving force behind this study. Great-speed data transfer, increased quality of service (QoS), reduced latency and high coverage are all provided as a consequence of the 5G network. The three main types of 5G services include:

1.1.1 Extensive mobile broadband

Streaming UltraHD movies, virtual reality and augmented reality (AR/VR) material, as well as high-speed internet access and increased bandwidth are all possible with this non-standalone design.

1.1.2 Massive machine type communication (MTC)

For a very low price, it allows long distance and broadband connection between machines. The MTC may be used by IoT applications to achieve a service with a fast data rate, low battery consumption, greater coverage, and simpler equipment. Because of its high quality of service, standard mobile network design is unable to deliver quickly with advanced service. There are just some of the applications that may benefit from on-demand and real-time interaction capabilities.

1.2 LTE Application

It's a recent trend to use a PIN diode to reconfigure antennas for WWAN and LTE. Because the diode's DC control circuit requires more space as well as increased loss, its practical use is limited. With the multi-mode resonance technology, antenna optimization becomes much easier. MIMO antennas have attracted a lot of interest in millimeter-wave communication as a result of the rising requirement for high data rates [4, 5].

Many different strategies of increasing packing density and improving radiator isolation have been explored by scientists. Wireless communication systems might benefit greatly from improving mutual coupling. A minimum of two radiating components are used in a MIMO antenna, which is situated at a certain distance to ensure the least possible mutual coupling. However, front-end current communication systems have a limited amount of space. It's been suggested by the researcher that a variety of methods may be used to lessen mutual coupling between the radiators [6].

1.3 Limitations of Existing Surveys

In the past, surveys have concentrated on architectural concerns, essential ideas, and implementation difficulties. The old surveys are not measuring current scenario domain and problems with recent breakthroughs in the present surveys, which concentrated on 5G technologies with distinct characteristics. Others, on the other hand, concentrated on millimeter-wave beam shaping (mmWave). In addition, the current study did not include all of the 5G network's research and development technologies. There is presently no comprehensive market study that covers all of the 5G network technologies and trade-offs that have been released so far. So, the primary goal is to provide an in-depth examination of all of the 5G MIMO antenna technology.

This study, on the other hand, focuses on the most up-to-date methods and ground breaking discoveries made by researchers in the field. The development and manufacture of 5G items are being covered in a number of recent noteworthy articles. Using this survey article as a reference, you may learn about the latest developments in 5G technology. Figure

1 depicts the survey in a logically organized manner. Surveys conducted on the various 5G network technologies are compared here in an up-to-date manner [7-10].

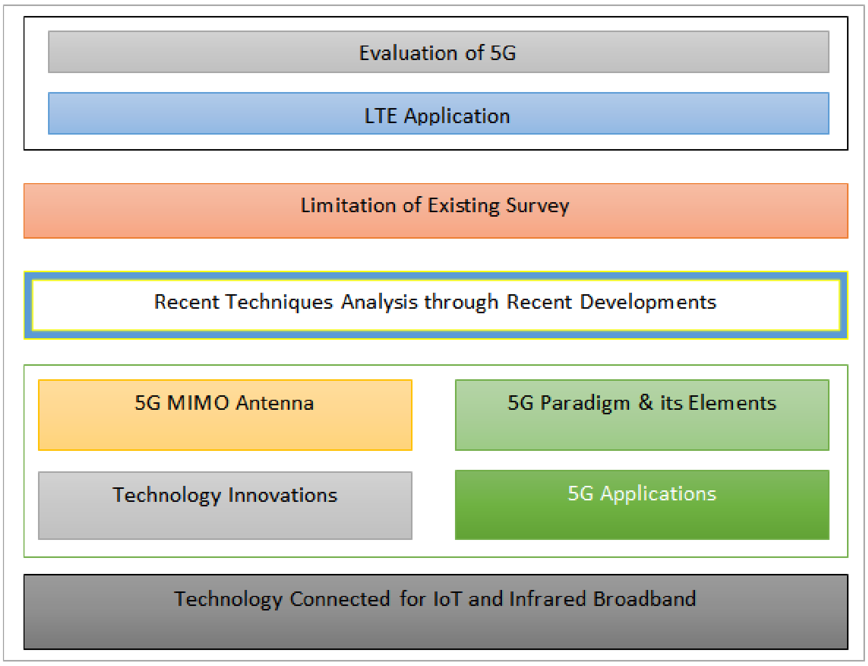

Figure 1. Systematic Review Layout of Article

2. Organization of the Article

The following is how the different sections of the research paper are organized: The previous scientific work with huge MIMO antennas is presented in Section 3. In the next section, we will evaluate new 5G paradigms and analyze their implications for future trends and applications. The conclusion and recommendations for moving forward are presented in Section 5.

3. Literature Survey

Li et al. describe a broadband antenna with several resonant modes for mobile phone applications, although the design required a wide clearing space. The clearance area is reduced by folding the antenna into a three-dimensional structure. Although this minimizes the antenna's lateral footprint, it necessitates greater vertical space and raises the manufacturing challenge [11]. Liu, L. et al. recommend employing minor part is placed in the horizontal stubs which was vertically mounted radiators to minimize mutual coupling. An ultra-wideband isolation of > 16 dB was suggested in 6 for a tree-shaped MIMO antenna configuration [12].

By modifying the construction of the minced horizontal underneath both resonator, Zhang, S. et al. hypothesized that isolation may be enhanced by more than 10 dB between diagonal and neighbouring components by making accessible domain. Nevertheless, the antenna's thickness restricted its application in many places arrays [13].

Sun, X. B. et al. presents to effectively eliminate from radiator impact by adjusting many parameters such as radiation pattern or gain. This may also be accomplished with the use of backward-radiating slits cut into the ground plane. Additionally, the ground plane was enhanced elaborately which result in increased isolation at the expense of fabrication difficulty [14].

Pilot contamination has been the subject of research by Elijah and others. Time division patterns are used in Massive MIMO pilot contamination Issues and Future Research Directions were addressed by the researchers. They also compiled a summary of the various techniques for obtaining the information [15].

Uplink and downlink services were described by Papadopoulos et al. in a huge MIMO system. A performance matrix is also kept to track the effect of pilot contamination on various performance metrics. To sum up their work on advanced massive MIMO, they regarded it critical and addressed a wide range of difficulties, including acquired data through certain frequencies [16].

For next-generation wireless communication using MIMO, Ramesh, M. et al. put up numerous ideas. Comparative research was conducted using many performance metrics, including maximum data rate, energy efficiency, latency, and overall throughput. The following are the major results of this study [17]:

- Increased mMIMO performance by concentrating on energy and spectrum performance;
- Explored potential hurdles to system design improvement.
- The use of spatial multiplexing results in increased energy efficiency.
- Improving throughput requires careful consideration in the design of MIMO.

For an efficient system sharing strategy, Zhou Y and his colleagues studied large-scale MIMO systems. Energy expenses on the circuit and transmission were taken into account while allocating resources. The optimization algorithms were also used to reducing the system's energy consumption during the simulation [18].

4. Evaluations from 4G to 5G

4.1 Cellular technology in the fourth generation (4G)

It is a standard for mobile broadband alone. Wider bandwidth up to 100 Mhz is possible because to the use of LTE and WiMAX technologies. A year ago, it was introduced.

4.2 LTE-A 4th Generation (4.5G)

Advancements in 4G technology have been included into LTE-A 4th Generation (4.5G). LTE-A employs MIMO technology, which combines several antennas for both transmitters and receivers, to improve signal reception and transmission. Multiple signals and antennas may operate together concurrently using MIMO, resulting in three times the speed of typical 4G over LTE-A. A number of other advantages came with LTE-A, including a higher system cap, less latency on the application server, and the ability to transmit three types of data simultaneously (data, audio, and video) wirelessly. Over 42 Mbps and up to 90 Mbps are possible with LTE-A.

4.3 Fifth generation (5G)

As a foundation for digital transformation, "Fifth generation" (5G) is a genuine upgrade above all prior mobile-generation networks. In addition to Extreme Mobile Broadband, 5G offers a variety of other services for consumers, such as Wi-Fi hotspots (eMBB). Among the numerous features it provides include the ability to broadcast UltraHD movies, more bandwidth, lower latency. It can provide up to 20 Gbps of downlink throughput. Additional 5G features include compatibility for both IPv6 and previous version [19]. Connecting to the internet at rapid rates, high throughput and low latency is possible because to 6 GHz 5G and small mmWave 5G antenna make up the majority of the technology.

4.4 5G Paradigms and Its elements

The Internet of Things (IoT) will be able to communicate with various devices at fast speeds, low latency, and on a massive scale thanks to 5G. It will also be possible to design new applications and industrial objectives using 5G's flexible paradigm. Many of the 5G network's features are outlined here, including:

4.5 Massive Machine - Machine infrastructures

The IoT, is a new feature of 5G that allows machines to form a infrastructures to define many application through human interaction. By connecting agriculture, construction, and industry, this service enhances the capabilities of 5G applications [20].

4.5.1 URLLC: ultra-low-latency communications

Real-time administration of machinery, high-speed communication between vehicles, and many self-sufficient activities are all included in this service. Remote medical treatment, surgeries, and operations are now all possible because to the development of low latency communications.

4.5.2 Enhanced mobile broadband

In the 5G system, mmWave and beam forming methods are used to provide high-speed connection in a wide variety of regions, which is a significant use case.

4.5.3 Community members

Smart homes, inventive schools, competent labs, safer and smarter autos, and excellent healthcare facilities may all benefit from 5G's ability to link numerous equipment over a highly flexible internet connection [21].

4.5.4 Businesses and economy

The frequency band of 24 to 100 GHz is used for 5G. Higher frequencies provide for safe, low-latency and high-speed.

4.5.5 Technological Innovations

New technologies including as beam forming, massive MIMO, mmWave, tiny cells and NOMA were brought to the market as a result of 5G. The VR, for example, enables users to feel as though they're in the same room as others who live thousands of miles away. With this 5G mobile network architecture, many new technologies have been introduced, such as smart homes, intelligent workplaces, innovative schools, and brilliant sports academies [22].

4.6 Several 5G Applications

4.6.1 high-capacity mobile broadband

Breakneck download rates of up to 10 to 20 Gbps are offered by 5G, which is a leap forward from all preceding mobile network technology. As a fiber-optic internet connection, the 5G wireless network may also be used.

4.6.2 Entertainment and multimedia

Video downloads accounted for more than half of all mobile internet traffic, according to a survey conducted in 2015. Streaming video will become increasingly prevalent in the future as a result of this trend. 5G will allow you to experience phone by streaming 4K movies with crystal clear audio at rapid speeds.

4.6.3 Internet of Things (IoT)

A wide range of things, such as appliances, sensors, devices, items, and software, will be linked to the internet through the Internet of Things (IoT). Because of, 5G will enable high-speed internet access. So, 5G is the best technology for Internet of Things. Additionally, it is a highly adaptable set-up that makes advantage of unused spectrum and can be set up at a very cheap cost.

4.6.4 Mission-critical and healthcare-related applications

Thanks to the advancements made possible by 5G technology, that physicians more easily communicate with doctors in a speed manner because to the advent of 5G. Chronically ill patients may now benefit from sophisticated medical gadgets being developed by researchers. Clever machines, the Internet of Things, smart sensors, high-definition image technologies and intelligent analytics systems will all benefit from the 5G network [23 - 25].

4.6.5 Infrared Broadband

The lack of ground-based base stations in many distant places means that 5G will be critical in bringing connection to these areas. The people will be able to communicate with each other through satellite systems when 5G is implemented. In order to link individuals in remote locations and urban centres all over the globe, the satellite network uses a collection of tiny satellites. Table 1 contains results of comparative investigation massive MIMO in 5G.

Table 1. Comparative investigation massive MIMO in 5G

S.No	Article	Throughput	Efficiency	Latency	Energy
1	[13]	Excellent	-	-	Average
2	[14]	Average	Good	Good	Excellent
3	[18]	Good	-	Excellent	Excellent
4	[16]	Excellent	Good	Average	Good
5	[17]	Average	Good	-	Good

5. Summary & Future Research Directions

This article has successfully presented an overview of the 5G research by exploring its different characteristics. Unlike previous generations of mobile networks, 5G networks offer services such as IoT, V2X, and Industry 4.0. Furthermore, the perspectives of different researchers are included in this study to provide a comprehensive review of 5G technologies, such as massive MIMO. The study also reveals that the technology that supports cellular communication is approaching the sixth generation, known as 6G. 6G necessitates a revolution in antenna design, as antennas need to be constructed for small wavelengths known as mm-waves, which can be readily accommodated in smartphones. It is also observed that the demand for 6G raises many challenges in its real-time implementation stage. For instance, rain produces high signal loss for millimetre waves, resulting in significant attenuation. To overcome the challenges, a further research investigation should be initiated on programmable, large-scale array antennas and radio frequency technologies, in addition to free space attenuation, high efficiency, and all space coverage antennas. New research initiatives should also be initiated to overcome the multiband and high integrated radio frequency circuit's low power consumption, low noise, and non-linearity. Many antenna types should be employed to enhance the effectiveness of 6G technologies. More research efforts should be initiated on 6G technologies to enable communication over very long distances with a very low latency of 1 millisecond. A future 6G driven wireless network will have a bit rate of about 1 Tbps per user and will deliver wireless connectivity a thousand times faster than 5G networks.

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Author's biography

S. R. Mugunthan is presently working as an Associate Professor, in the Department of Computer Science and Engineering, in Sri Indu College of Engineering and Technology, Hyderabad, India. His area of research includes ubiquitous networks, Big Data Analytics, Industrial System and Collective Intelligence on all fields of Computing and Communication Technologies.